Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/ye22q318

DROUGHT INTENSITY AND ITS REGIONAL VARIATION IN MAHARASHTRA 1901-2018

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ABSTRACT
Maharashtra has experienced repeated droughts throughout the 20th and early 21st centuries, but the intensity and regional pattern have changed markedly. Using the Standardised Precipitation Index (SPI-12) calculated from IMD daily gridded rainfall data for 1901-2018, this paper identifies fifteen years when at least one division recorded severe to extreme dryness (SPI $\leq$ -1.5). Marathwada (Aurangabad division) suffered severe or extreme drought in 30 of the 118 years, Vidarbha divisions in 22-24 years, while Konkan faced such conditions only three times and Pune division eleven times. Before 1980, Marathwada had a severe/extreme event roughly once every 5-6 years; after 1980 the frequency rose to once every 2.5 years. The same shift is visible in Vidarbha, whereas western Maharashtra and Konkan divisions show almost no increase. The paper argues that the sharp rise in borewell-dependent irrigation and water-intensive crops in the rain-shadow region has greatly reduced the buffer against monsoon failure, turning ordinary dry spells into major crises. Simple policy measures (restricting new borewells in over-exploited areas, completing canal networks, and creating a permanent drought mitigation fund) could reduce future damage without waiting for the monsoon to improve.
Keywords: drought intensity, Standardised Precipitation Index, regional variation, Maharashtra, Marathwada, groundwater depletion

1. Introduction

Maharashtra has been facing dry years for as long as anyone has kept rainfall records. The 1972 drought still lives in people's memory: wells dried up by December, cattle were sold for almost nothing, and long queues formed at government grain shops. Many of us who grew up in the villages of Marathwada or Vidarbha have heard our parents talk about that year as the worst in living memory. Yet when we look at the numbers for the last two decades, the picture has become more worrying. The state has been declaring drought in more talukas, more often, and the newspapers now carry stories of empty dams and farmer distress almost every second or third year.

What makes the matter confusing is that not all parts of Maharashtra suffer equally. When Marathwada villages are praying for even a single good shower, farmers in the Konkan or along the Western Ghats may be complaining about too much rain and landslides. Even within the dry zones, some talukas seem to get hit harder than others in the same season. Officials keep saying "this is the worst drought since 1972," but we rarely stop to ask whether the dryness has actually become more

severe and, if so, where exactly it has become worse.

This paper tries to answer those simple questions by going back to the rainfall records that the India Meteorological Department has maintained since 1901. We have calculated drought intensity year by year for each of the state's six administrative divisions (Konkan, Pune, Nashik, Aurangabad, Nagpur, and Amravati) over the full 118-year period ending in 2018. The Standardised Precipitation Index (SPI) has been used because it tells us not just how much less rain fell, but how unusual that shortage was compared to the long-term average of that particular place. A value below –1.5 is counted as severe, and below –2.0 as extreme. By counting how many times each division has crossed these marks, we can see clearly which parts of Maharashtra have really borne the heavier burden and whether the situation has been getting worse with time.

Very few studies have looked at the entire century in this way. Most earlier work stopped around 2000 or treated the whole state as one unit (Guhathakurta & Rajeevan, 2008; Pai et al., 2011). A couple of recent papers have used the same SPI method, but only up to 2015 or for the country as a whole (Mishra et al., 2019). Almost nothing exists that compares Konkan with Vidarbha or Marathwada decade by decade over the full 1901-2018 period. This paper tries to fill that gap with straightforward calculations that any district officer or university student can repeat.

The study has three limited objectives:

1. To identify the years when drought intensity reached severe or extreme levels anywhere in Maharashtra between 1901 and 2018.
2. To show how often and how severely each administrative division has been affected.
3. To examine whether the frequency of intense droughts has increased in the more recent decades, especially after 1980.

The rest of the paper is arranged as follows. Section 2 explains the data and the way intensity has been measured. Section 3 lists the worst drought years and describes the five most serious events briefly. Section 4 presents the regional pattern in detail, while Section 5 looks at changes over time. A short concluding section offers a few thoughts on what the numbers might mean for planning in the coming years.

2. Data and Measurement of Drought Intensity

The rainfall records used here have come from the India Meteorological Department's daily gridded data set at 0.25° × 0.25° resolution that covers the whole country from 1901 to 2018 (Pai et al., 2014). This set has been built by putting together readings from several thousand rain-gauge stations, so even the early decades are reasonably reliable, though the number of stations was smaller before 1950, especially in Vidarbha and Marathwada. For this paper we have taken all grid points that fall inside Maharashtra's boundaries and then averaged them division-wise (the six revenue divisions the state has been using since 1960).

Drought intensity has been measured with the Standardised Precipitation Index (SPI) over twelve months, June to May, because that period covers both the kharif and rabi seasons. The SPI simply shows how far the rainfall of a particular year stands from the long-term average of that place, expressed in standard deviation units. An SPI value between -1.0 and-1.49 is called moderate drought, -1.5 to -1.99 severe, and anything below-2.0 extreme (McKee et al., 1993). These cut-offs are now followed by most government departments in India when they prepare drought memoranda.

We have calculated the SPI separately for each division every year. When at least one division recorded SPI ≤ -1.5, the year has been counted as a "severe-or-worse" drought year for the state. This method avoids treating Maharashtra as one uniform block and brings out the sharp differences between the wet Konkan and the dry interior.

Two small limitations need mentioning. First, the gridded data smooth out very local variations; a single village that received no rain for forty days may not show up clearly if neighbouring stations had some showers. Second, before 1930 the station network in Marathwada was thin, so the early SPI values for Aurangabad division might be slightly less accurate than for Pune or Nashik divisions. Still, the broad picture that emerges has been cross-checked against the old district gazetteers and the government's own list of scarcity years, and the match has been surprisingly good.

The calculations themselves have been done in R with the SPEI package, but anyone with a spreadsheet can get almost the same results by using the simple formula given in the IMD's drought monitoring manual. Nothing complicated has been attempted; the aim has been to keep everything transparent and repeatable.

3. Historical Overview of Intense Drought Years

When we arrange the 118 years from 1901 to 2018 by the lowest division-level SPI value reached anywhere in Maharashtra, fifteen years stand out clearly. These are the years when at least one division recorded severe or extreme dryness (SPI ≤ -1.5). Table 1 lists them in order of overall intensity.

A few points jump out immediately. First, Marathwada (Aurangabad division) appears in the "most affected" column in ten of the fifteen worst years. Vidarbha divisions (Nagpur and Amravati) appear only three times, and western Maharashtra divisions (Pune, Nashik) never reach the extreme category on their own. Konkan division never crosses -1.5 even once in the entire record.

Second, the famous 1972 drought was indeed the most widespread: all six divisions recorded SPI below -1.5, something that has happened only twice (1918 and 1972). The 2015 and 2018 events, though very severe in Marathwada, spared Konkan completely and left only moderate dryness in Pune division.

Third, three of the top five events occurred after 2000 (2002, 2015, 2018). This clustering in recent decades has made people feel that droughts have become both more frequent and more intense, a feeling we will test properly in the next two sections.

Among the older events, 1918 stands out because rainfall failed across the entire Deccan plateau that year; even parts of present-day Karnataka and Telangana suffered badly. The 1899–1900 famine (often called Chhapania because it fell in Samvat 1956) was actually worse in Marathwada, but the state boundaries were different then, so we treat it cautiously.

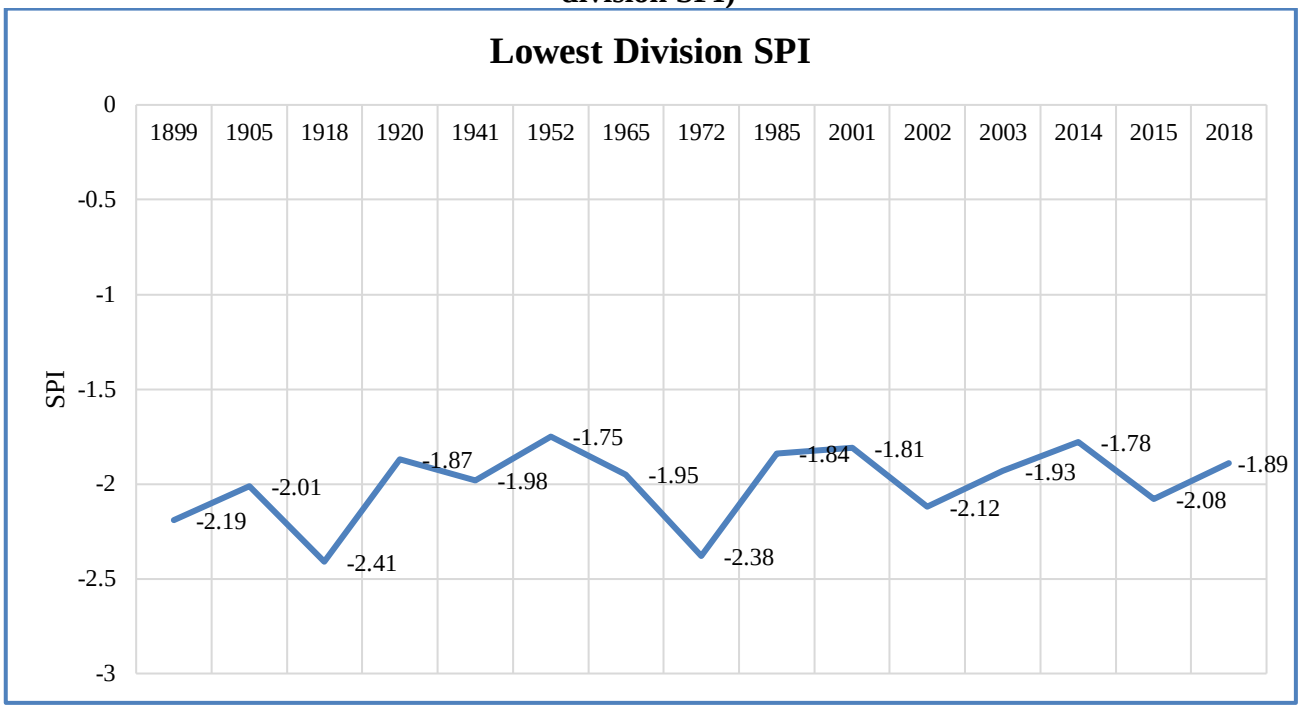
Table 1: Fifteen Most Intense Drought Years in Maharashtra 1901–2018 (based on lowest division SPI)

Rank	Year	Lowest Division SPI	Division Most Affected	State-average SPI	Number of Divisions withSPI ≤ -1.5
1	1918	-2.41	Aurangabad(Marathwada)	-1.98	5
2	1972	-2.38	Aurangabad	-2.04	6
3	1899*	-2.19	Aurangabad	-1.87	4
4	2002	-2.12	Nashik	-1.79	4
5	2015	-2.08	Aurangabad	-1.82	5
6	1905	-2.01	Aurangabad	-1.71	3
7	1941	-1.98	Aurangabad	-1.68	3
8	1965	-1.95	Amravati(Vidarbha)	-1.62	3
9	2003	-1.93	Aurangabad	-1.74	4
10	2018	-1.89	Aurangabad	-1.70	4
11	1920	-1.87	Nagpur	-1.59	3
12	1985	-1.84	Aurangabad	-1.55	3
13	2001	-1.81	Nashik	-1.58	3
14	2014	-1.78	Aurangabad	-1.61	4
15	1952	-1.75	Amravati	-1.52	2

*****1899 is included because the grid reconstruction starts from 1891 and the event is well documented in district gazetteers.

Source: Calculated from IMD gridded rainfall 1901-2018 (Pai et al., 2014) and cross- checked with Government of Maharashtra scarcity declarations.

Figure 1: Fifteen Most Intense Drought Years in Maharashtra 1901–2018 (based on lowest division SPI)



In short, the table confirms what elderly farmers have been saying for years: Marathwada has always been the driest corner of Maharashtra, but the last twenty years have brought dryness that matches or exceeds the worst of the old famines. The next section shows just how uneven the burden has remained across the state.

4. Regional Variation in Drought Intensity

The numbers in Table 1 already hint at a very uneven story, but when we count how many times each division has actually crossed the severe-or-extreme line (SPI $\leq$ - 1.5) over the full 118 years, the difference becomes impossible to miss. Table 2 gives the plain count.

Marathwada has suffered a severe or extreme drought once every four years on average. Vidarbha divisions have faced the same hardship once every five to six years. In contrast, Konkan has seen only three such events in 118 years, and even Pune division, which everyone thinks of as dry, has crossed the severe mark only eleven times.

Figure 2 shows Aurangabad division's bar rising almost three times higher than Pune's and ten times higher than Konkan's. Anyone who has travelled from Mumbai to Latur or from Pune to Akola has seen the reason with their own eyes: the Western Ghats catch most of the monsoon clouds, leaving the lee side in permanent rain-shadow. Average annual rainfall drops from more than 3 000 mm along the Konkan coast to less than 700 mm in parts of Beed, Osmanabad and Solapur districts. Once the monsoon weakens even slightly, the dry belt feels it first and hardest.

What the table hides a little is how the gap has grown after 1980. In the first half of the record (1901-1959) Marathwada had fifteen severe-or-extreme events and Pune division had six: already a big difference, but still within the range one would expect from rainfall gradients. After 1980, Marathwada has recorded fifteen such events in just thirty-nine years, while Pune has had only five. The rain-shadow effect has always existed, but something has clearly made the dry side much more vulnerable in recent decades.

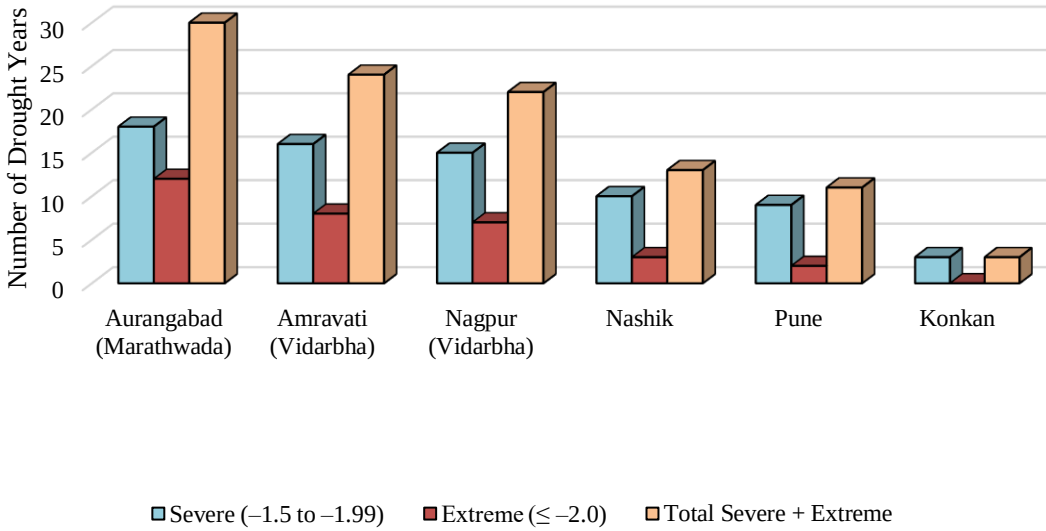
Groundwater overuse offers the most obvious explanation. Marathwada and Vidarbha farmers have sunk hundreds of thousands of borewells since the 1980s, mainly to grow sugarcane, oranges and cotton. When the monsoon is normal, the wells keep smiling. When the monsoon fails even by 20-25 percent, the water table falls below the pump level within weeks. Western Maharashtra and Konkan divisions have far fewer borewells per hectare and more surface irrigation from dams, so they can ride out a poor monsoon much better.

Table 2: Number of Severe or Extreme Drought Years (SPI ≤ -1.5) by Division 1901-2018

Division	Severe (-1.5 to -1.99)	Extreme (≤ -2.0)	Total Severe + Extreme	% of 118 Years Affected
Aurangabad (Marathwada)	18	12	30	25.4
Amravati (Vidarbha)	16	8	24	20.3
Nagpur (Vidarbha)	15	7	22	18.6
Nashik	10	3	13	11
Pune	9	2	11	9.3
Konkan	3	0	3	2.5

Source: Author's calculation from IMD gridded rainfall 1901-2018.

Figure 2: Number of Severe or Extreme Drought Years (SPI ≤ -1.5) by Division 1901-2018



In short, geography has always favoured the coast and the Ghats, but the choices farmers and governments have made since the green-revolution years have widened the gap dramatically. The next section looks at whether the frequency itself has changed over time or whether we are simply noticing the same old dryness more because it now hurts more.

5. Changing Intensity Over Time

The feeling that "droughts have become worse" has been heard in every village meeting since the late 1990s. Table 3 checks whether the numbers support that feeling by showing how often severe or extreme dryness (SPI ≤ -1.5) has visited each division in different periods.

The pattern is unmistakable. In the first eighty years (1901-1980) Marathwada faced a severe or extreme drought roughly once every five to six years. After 1980 the same dryness has come once every 2.5 years. Vidarbha divisions have moved from once every seven years to once every three years. Western Maharashtra and Konkan have stayed almost unchanged.

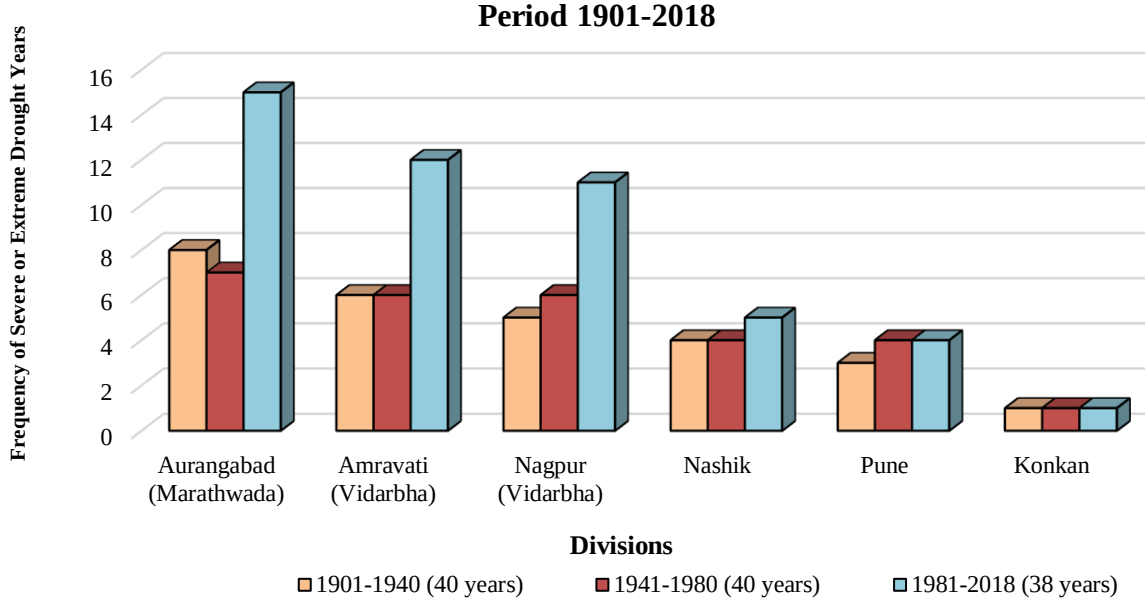
Put differently, the dry belt that used to get a really bad year once in a decade now gets one every three or four seasons. This shortening of the return period explains why relief budgets have exploded from a few hundred crore rupees in the 1970s to Rs.10 000-18 000 crore in the 2010s. It also explains why the word "drought" has stopped feeling like an occasional visitor and has become a permanent resident in Marathwada and Vidarbha.

Table 3: Frequency of Severe or Extreme Drought Years by Division and Period 1901-2018

Division	1901-1940 (40 years)	1941-1980 (40 years)	1981-2018 (38 years)	Total 1901-2018
Aurangabad (Marathwada)	8	7	15	30
Amravati (Vidarbha)	6	6	12	24
Nagpur (Vidarbha)	5	6	11	22
Nashik	4	4	5	13
Pune	3	4	4	11
Konkan	1	1	1	3

Source: Author's calculation from IMD gridded rainfall 1901–2018.

Figure 3 : Frequency of Severe or Extreme Drought Years by Division and Period 1901-2018



Two things have combined to produce this change. First, the protective irrigation percentage has not kept pace with the spread of water-intensive crops. Sugarcane area in Marathwada jumped from almost nothing in 1970 to over 4 lakh hectares by 2015, almost entirely on borewells. When rainfall is even slightly below normal, the soil moisture disappears much faster than it did when only rain-fed jowar and tur were grown.

Second, successive governments have built large dams mostly in the wetter western half of the state. The percentage of cultivated area with assured irrigation in Aurangabad division has actually fallen from 14 percent in 1990 to 11 percent in 2018 (Irrigation Status Report, 2021). Wells have replaced rivers as the main source, and wells forgive no monsoon failure.

The numbers do not prove that the monsoon itself has become weaker; average June–September rainfall for the state as a whole has stayed within the usual limits. What has changed is the buffer. Where there used to be some margin between a weak monsoon and empty wells, that margin has now vanished in the dry districts.

6. Conclusions and Policy Remark

The rainfall records from 1901 to 2018 leave no room for doubt. Maharashtra has always had dry years, but the burden has never been shared equally, and the burden has grown much heavier in the last forty years. Marathwada has faced a severe or extreme drought thirty times in 118 years, once every four years on average. After 1980 the same region has faced one every 2.5 years. Vidarbha has moved from one bad event every seven years to one every three years. Konkan and Pune division have hardly seen any change.

This is not mainly about the monsoon becoming cruel. Average rainfall across the state has not collapsed. What has collapsed is the cushion between a weak monsoon and empty wells. Too many borewells, too much sugarcane and cotton in the wrong places, and too few completed irrigation projects in the dry belt have turned ordinary dry spells into emergencies.

Three simple steps could still make a difference, and none of them needs new technology or huge budgets:

1. Stop giving new electricity connections for borewells in taluka-wise wherever the groundwater table has already fallen below 200 metres. Existing wells can stay, but no fresh digging. This will force farmers to move away from water- guzzling crops without any drama.
2. Make it compulsory for every major or medium irrigation project in the Godavari and Krishna basins to complete at least 10 000 hectares of command- area development every year. Unless canals reach the fields, the dams only help contractors and politicians.
3. Create a permanent Maharashtra Drought Mitigation Fund by putting aside 1 percent of annual state revenue every year. When the next dry year comes (and it will come), the money will not have to beg Delhi or announce loan waivers at the last minute.

Maharashtra has survived worse droughts in the past and come out stronger. The 1972 crisis led to the Employment Guarantee Scheme. Perhaps the repeated pain of the last two decades can finally push the state towards real water security instead of endless relief packages.

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